DOI: 10.7860/JCDR/2022/53713.16678

Original Article

Physiology Section

Effect of Stress on Heart Rate Variability in Medical Students: A Cross-sectional Study

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ABSTRACT

Introduction: Medical education can impose significant psychological stress on undergraduate students. A considerable degree of psychological morbidity has been reported among medical students ranging from stress, interpersonal problems, and suicidal ideation to psychiatric disorders and they tend to have greater psychological distress than the general population. Stress is one of the factors known to cause variation in heart rate variability. Heart Rate Variability (HRV) is a proven reliable non invasive marker of cardiovascular health and has been used in cardiovascular risk stratification.

Aim: To study the effect of stress on heart rate variability in medical students.

Materials and Methods: This cross-sectional study was conducted in the Department of Physiology at JSS Medical College, Mysuru, Karnataka, India, from December 2017 to February 2018. Total 58 healthy first year MBBS medical students aged between 18-25 years with normal Body Mass Index (BMI) were included in the study. The Medical Student Stressor Questionnaire (MSSQ), a validated instrument to identify sources of stress in medical students were used to assess the level of stress. AD Instruments PowerLab (Data Acquisition System) was used to record the frequency and time domain analysis of HRV from the limb leads. Kruskal-Wallis test was applied to assess the association between stress domains and HRV domains, using Statistical Package for Social Sciences (SPSS) version 23.0.

Results: Most of the medical students had mild to moderate degrees of stress in all the domains of the MSSQ. There was no statistically significant (p-value >0.05) association found between domains of stress with the time and frequency domains of the HRV.

Conclusion: Though it was found that medical students were exposed to significant stressors during their medical training, the stress was of mild to moderate degree which had no significant effect on HRV.

Keywords: Medical student stressor questionnaire, Stressors, Sympathovagal balance

INTRODUCTION

Stress is one of the integral part of the present competitive world. It is present in day to day life of an individual be it academic, household, job related or interpersonal. Medical education can impose stress on an individual who has just entered the medical school with ocean of syllabus to learn, adjusting to the new environment, making new friends and so on. Stress can be a double edge sword with mild degree of stress required to improve the performance of the individual, but as the stress level increases it causes distress thereby reducing the performance of the individual [1-4]. So it is imperative for an individual to cope up with stress and to manage it appropriately to lead a healthy life.

Increased stress is known to cause health problems and studies have shown that increased stress level can lead to development of non communicable diseases like diabetes mellitus, cardiovascular diseases, obesity among others [5]. Stress can also take a toll on mental health thereby predisposing an individual to develop depression, mental fatigue, suicidal ideation and other mental disorders [6,7,8]. Stress is an inevitable part of medical education as medical students have to cope up with humongous academics, interpersonal relation, social related, group activities, desire driven activities, teaching and learning related stressors.

Stress is known to impact autonomic balance. Heart Rate Variability (HRV) is one of the validated measures to know about the sympathovagal balance [9]. Heart rate variability is the measure of changes in time that happens between successive heart beats. The time is measured in milliseconds (ms) and called as RR interval or interbeat interval [10]. The HRV reflects the heart brain interactions and the dynamic variability of the autonomic nervous system. Time domain indices of HRV measure the inter beat interval variability. Frequency domain indices mainly considers the power which is the signal energy found within a frequency band. This makes the power spectral analysis a quantitative marker of autonomic function of the heart [10]. The present study was undertaken to assess the association between stress and heart rate variability in medical students with the hypothesis that stress affects the sympathovagal balance of the human body. This study was a part of a larger project carried out in the Department of Physiology of the institute [4].

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Physiology at JSS Medical College, Mysuru, Karnataka, India, from December 2017 to February 2018. Written informed consent was obtained from all the participants. The study was approved by Institutional Ethical Committee (JSSMC/IEC/04/4295/2016-17).

Inclusion criteria: First year MBBS students who were aged between 18-25 years with normal Body Mass Index (BMI) (18.5-22.9 kg/m^2) were included in the study.

Exclusion criteria: The students who were smokers, alcoholics, regular exercisers, on any drugs and subjects with mental illness, co-morbidities were excluded from the study.

Convenient sampling technique was used. Body mass index was measured in 200 students and history was taken with baseline recording of Blood Pressure (BP) and only subjects with normal BP were included. The students who did not satisfy inclusion criteria were excluded from the study. Hence the final sample size taken for the study was 58. Only the first year students were considered because they have entered a new arena of medical education which is quite different from the school education and can cause a lot of stress; as time passes the students get accustomed to medical education and the stress level may decrease.

Medical Student Stressor Questionnaire (MSSQ)

To assess the stress level in medical students, a validated instrument, the Medical Student Stressor Questionnaire (MSSQ) which is a freely available questionnaire, was used [11]. The questionnaire is available in English language and was administered in the same language. Based on literature available, the items of MSSQ were designed and grouped into six main domains and distribution of 40 questions were as following [11]:

1. Stress domain 1: Academic Related Stressor (ARS)- 13 questions
2. Stress domain 2: Intrapersonal and Interpersonal Related Stressor (IRS)- 7 questions
3. Stress domain 3: Teaching and Learning Related Stressor (TLRS)- 7 questions
4. Stress domain 4: Social Related Stressor (SRS)- 6 questions
5. Stress domain 5: Drive and Desire Related Stressor (DRS)- 3 questions
6. Stress domain 6: Group Activities Related Stressor (GARS)- 4 questions

Subjects were asked to rate each source by choosing from five responses:

- "causing no stress at all",
- "causing mild stress",
- "causing moderate stress",
- "causing high stress" and
- "causing severe stress"

The scoring method assigns marks from 0 to 4 to each of the responses respectively.

- 0-1 was considered as mild stress,
- 1.01-2 was considered as moderate stress,
- 2.01-3 was considered as high stress and
- 3.01-4 was considered as severe stress.

AD Instruments PowerLab (Data Acquisition System) was used to record the frequency and time domain analysis of HRV from the limb leads. The HRV analysis was done as per the guidelines issued by Task force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology [12,13]. HRV analysis was done only once.

- Time domain indices in milliseconds includes SDNN- Standard Deviation of the all NN interval,
- rMSSD- square root of the mean of the sum of the squares of differences between adjacent NN interval,
- pNN50(%)- percentage of difference between adjacent NN intervals that are greater than 50 ms.
- Frequency domain indices includes:

  Low Frequency (LF) Absolute Values (AV) in ms^2

  High Frequency (HF)- AV in ms^2

  LF/HF (Low Frequency/ High Frequency) ratio

STATISTICAL ANALYSIS

Kruskal-Wallis test was applied to know the association between stress domains and HRV domains, using Statistical Package for Social Sciences (SPSS) version 23.0. A p-value less than 0.05 in each of the domains was considered as significant.

RESULTS

The medical students had mild to moderate degree of stress in all the six domains as assessed using MSSQ. Frequency domain parameters LF and HF were reduced whereas LF/HF ratio was within normal range. Time domain parameters SDNN was reduced but RMSSD, pNN50 were within normal range. Kruskal-Wallis test was applied to assess the association between stress domains and HRV parameters. The ARS caused moderate degree of stress in maximum number (n=32) students and there was no significant association between HRV parameter and ARS (p-value >0.05) [Table/Fig-1].

The IRS also caused moderate degree of stress in maximum number (n=27) of students but was not significantly (p-value >0.05) associated with HRV parameters [Table/Fig-2]. The TLRS also caused moderate degree of stress in maximum number (n=25) of students but was not significantly (p-value >0.05) associated between HRV parameter and TLRS [Table/Fig-3]. The SRS also caused moderate degree of stress in maximum number (n=30) of students but was not significantly (p-value >0.05) associated between HRV parameters [Table/Fig-4]. The DRS caused mild degree of stress in maximum number of students and there was no significant association with HRV parameters (p-value >0.05) [Table/Fig-5]. The GARS also caused moderate degree of stress in maximum number (n=24) of students but was not significantly (p-value >0.05) associated between HRV parameters [Table/Fig-6].

	Median and IQR scores in different grades of stress									
	Mild (n=5)		Moderate (n=32)		High (n=17)		Severe (n=4)			
Parameters	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Total	p-value*
LF (ms^2)	290.65	548.49	563.405	1173.395	108.4	498.43	1163.1	13028.28	58	0.077
HF (ms^2)	266	755.155	539.18	1981.065	38.01	616.3	1683.5	13571.37	58	0.066
LF/HF	1.09	1.33	1.04	2.0075	2.36	3.425	0.745	0.375	58	0.267
Mean NN (ms)	648.6	428.35	654.5	274.35	482.4	192.85	635.8	447.375	58	0.418
Median NN (ms)	644.6	470.55	669.25	282.8	533.9	147.1	628.9	424.75	58	0.367
SDNN (ms)	53.8	97.315	46.4	92.175	85.5	110.75	52.25	54.65	58	0.874
RMSSD (ms)	39	92.675	47.5	111.65	89.2	113.55	44.4	39.075	58	0.744
pNN50 (%)	43	74.5	31.5	41.25	32	49	15	33.25	58	0.827

[Table/Fig-1]: Stress domain 1 (ARS) verses HRV parameters.
*Kruskal-Wallis test; ARS: Academic related stressors; HRV: Heart rate variability; LF: Low frequency power; HF: High frequency power; NN: Time interval between R peaks; SDNN: Standard deviation of NN interval; RMSSD: Root mean square of successive RR interval differences; pNN50: Percentage of successive RR intervals that differ by more than 50 ms

	Median and IQR scores in different grades of stress									
	Mild (n=25)		Moderate (n=27)		High (n=5)		Severe (n=1)			
Parameters	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Total	p-value*
LF (ms^2)	257.75	721	504.91	973	418.69	17305.9	2204	0	58	0.564
HF (ms^2)	266	873	408.24	1491	215.33	12034.2	3124	0	58	0.5
LF/HF	1.16	2.32	0.89	2.2	0.97	1.7	0.7	0	58	0.589
Mean NN (ms)	576.1	258	624	319	579.7	343.85	691.9	0	58	0.789

Median NN (ms)	582.6	247	625.6	305	583.4	268.2	677.7	0	58	0.82
SDNN (ms)	53.8	83	79.8	89	35.2	130.95	67.2	0	58	0.743
RMSSD (ms)	39	91.4	81.8	111	32.2	114	49.8	0	58	0.555
pNN50 (%)	39	42.5	28	45	10	35.5	43	0	58	0.506

[Table/Fig-2]: Stress domain 2 (IRS) verses HRV parameters.
*Kruskal-Wallis test; IRS: Interpersonal related stressors; HRV: Heart rate variability; LF: Low frequency power; HF: High frequency power; NN: Time interval between R peaks; SDNN: Standard deviation of NN interval; RMSSD: Root mean square of successive RR interval differences; pNN50: Percentage of successive RR intervals that differ by more than 50 ms
The IQR has not been calculated as the number of observations in the severe grade was less than 4

	Median and IQR scores in different grades of stress									
	Mild (n=23)		Moderate (n=25)		High (n=8)		Severe (n=2)			
Parameters	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Total	p-value*
LF (ms^2)	263.26	714	532.6	1199	338.17	2147	1120.945	-	58	0.86
HF (ms^2)	289.74	1052	329.8	2465	366.2	1083	1585.74	-	58	0.983
LF/HF	1.01	2.32	1.7	2.15	0.97	2.05	0.745	-	58	0.741
Mean NN (ms)	529	212	544.9	317	639	442	635.8	-	58	0.965
Median NN (ms)	564	284	611.6	269	645	450	628.9	-	58	0.994
SDNN (ms)	53	93.2	80	92.2	39.05	46.4	41.85	-	58	0.495
RMSSD (ms)	46	116	81.8	91.6	31.25	41.4	29.45	-	58	0.34
pNN50 (%)	36	40	28	44.5	13	29.8	22.5	-	58	0.36

[Table/Fig-3]: Stress domain 3 (TLRS) verses HRV parameters.
*Kruskal-Wallis test; TLRS: Teaching learning related stressors; HRV: Heart rate variability; LF: Low frequency power; HF: High frequency power; NN: Time interval between r peaks; SDNN: Standard deviation of NN interval; RMSSD: Root mean square of successive RR interval differences; pNN50: Percentage of successive RR intervals that differ by more than 50 ms
The IQR has not been calculated as the number of observations in the severe grade was less than 4

	Median and IQR scores in different grades of stress									
	Mild (n=20)		Moderate (n=30)		High (n=8)		Severe (n=0)			
Parameters	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Total	p-value*
LF (ms^2)	287.855	1034	263.625	751	1075.34	2581	-	-	58	0.149
HF (ms^2)	430.5	2560	207.875	737	1138.7	2597	-	-	58	0.115
LF/HF	0.995	2.49	1.68	2.14	0.745	1.82	-	-	58	0.55
Mean NN (ms)	552.55	276	563.55	297	636.8	250	-	-	58	0.683
Median NN (ms)	598.25	287	597.5	291	632.85	145	-	-	58	0.836
SDNN (ms)	56.65	96.1	46.9	94.4	61.4	58.6	-	-	58	0.733
RMSSD (ms)	54.5	108	43.2	112	53.3	61.5	-	-	58	0.936
pNN50 (%)	43	50.8	28	46.5	23	30.3	-	-	58	0.375

[Table/Fig-4]: Stress domain 4 (SRS) verses HRV parameters.
SRS: Social related stressors; HRV: Heart rate variability; LF: Low frequency power; HF: High frequency power; NN: Time interval between R peaks; SDNN: Standard deviation of NN interval; RMSSD: Root mean square of successive RR interval differences; pNN50: Percentage of successive RR intervals that differ by more than 50 ms

	Median and IQR scores in different grades of stress									
	Mild (n=41)		Moderate (n=14)		High (n=2)		Severe (n=1)			
Parameters	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Total	p-value*
LF (ms^2)	290.65	676	600.515	2309	697.9035	-	16715	0	58	0.419
HF (ms^2)	266	782	718.385	2608	1196.072	-	17182.3	0	58	0.354
LF/HF	1.09	2.04	0.93	2.41	0.565	-	0.97	0	58	0.492
Mean NN (ms)	544.9	264	617.85	286	661.95	-	147.9	0	58	0.364
Median NN (ms)	611.6	265	632.85	234	657.7	-	172.2	0	58	0.42
SDNN (ms)	48	85	106.05	170	45.4	-	79.4	0	58	0.461
RMSSD (ms)	41.6	91.4	90.75	128	43.15	-	57.6	0	58	0.636
pNN50 (%)	36	45.5	30	41.3	6	-	10	0	58	0.31

[Table/Fig-5]: Stress domain 5 (DRS) verses HRV parameters.
*Kruskal-Wallis Test
DRS: Drive and desire related stressors; HRV: Heart rate variability; LF: Low frequency power; HF: High frequency power; NN: Time interval between R peaks; SDNN: Standard deviation of NN interval; RMSSD: Root mean square of successive RR interval differences; pNN50: Percentage of successive RR intervals that differ by more than 50 ms
The IQR has not been calculated as the number of observations in high and severe grades was less than 4

	Median and IQR scores in different grades of stress									
	Mild (n=23)		Moderate (n=24)		High (n=8)		Severe (n=3)			
Parameters	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Total	p-value*
LF (ms^2)	217.32	694	563.405	1091	214.555	536	2204	-	58	0.103
HF (ms^2)	215.33	539	694.185	2027	139.855	902	3124	-	58	0.067
LF/HF	1.76	2.42	0.875	2.16	1.17	2.42	0.79	-	58	0.214

Mean NN (ms)	544.9	239	603.1	303	572.3	331	579.7	-	58	0.885
Median NN (ms)	544.4	229	606.8	274	639.95	397	580.1	-	58	0.783
SDNN (ms)	53	92.7	69.7	88.3	76.55	179	67.2	-	58	0.6
RMSSD (ms)	41.6	116	74.6	88.9	59.05	124	49.8	-	58	0.737
pNN50 (%)	32	48	36	42	18	30.3	10	-	58	0.426

[Table/Fig-6]: Stress domain 6 (GARS) verses HRV parameters.
*Kruskal-Wallis test; GARS: Group activity related stressors; HRV: Heart rate variability; LF: Low frequency power; HF: High frequency power; NN: Time interval between R peaks; SDNN: Standard deviation of NN interval; RMSSD: Root mean square of successive RR interval differences; pNN50: Percentage of successive RR intervals that differ by more than 50 ms
The IQR has not been calculated as the number of observations in the severe grade was less than 4

DISCUSSION

The present study was done to assess the association between stress and HRV parameters. In the present study, medical students had mild to moderate degree of stress in all the six domains. There are studies which show that medical students suffer from moderate to severe degree of stress [14-16]. In all these studies conducted previously [14-16], the questionnaire used was perceived stress scale, which is a stress scale for assessing stress in general population and not specific to medical students. In the present study the stress level were low because the instrument used to assess stress was specifically designed and validated for medical students. The other reasons could be effective mentoring and student support provided in the college. Apart from this the students are also trained in life skills so that they can manage day to day stressors better. Additionally different individuals may respond to stressors in a varied way, therefore perceived stress may be low in the subjects of the present study.

The frequency domain parameters of HRV like LF and HF were reduced whereas LF/HF ratio was within normal range, which means there is no sympathovagal imbalance. Time domain parameters SDNN was reduced which indicates that sympathetic tone is reduced, but RMSSD, pNN50 were within normal range which indicates that parasympathetic tone was normal. The HRV parameters were within normal range in the present study as subjects with normal BMI were recruited since higher BMI itself may cause increase sympathetic tone thereby altering HRV.

There was no significant association between the stress domains and HRV domains because the sampling technique used was convenient sampling and there were not many students in high and severe category in any of the stress domains. A study has shown that there is significant association between stress domain and HRV domains, but in that study the stress level of the individual was categorised as mild, moderate, high or severe based on the highest grade of stress in any one of the domains of the MSSQ [12]. But in the present study individual domains of stress were not associated with the HRV parameters.

Limitation(s)

In the present study, only 58 subjects were included and assessed for stress levels. Studies with larger sample size across institutions needs to be done to generalise the results to the target population.

CONCLUSION(S)

Though medical students are exposed to significant stressors like change in academics, peers, desires, interpersonal and intrapersonal relationship during their medical training, these stressors cause little stress which is of mild to moderate degree and this level of stress has no significant effect on HRV.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jan 12, 2022
- Manual Googling: Jan 19, 2022
- iThenticate Software: Apr 02, 2022 (15%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 04, 2022**
Date of Peer Review: **Jan 29, 2022**
Date of Acceptance: **Apr 09, 2022**
Date of Publishing: **Aug 01, 2022**